Disclaimer: this paper is designed to be a good-faith writeup of a multi-stakeholder workshop held under the Chatham House rule, with a degree of artistic licence for the writer to make it hopefully engaging for the reader. It does not represent the views of any individual person or organisation in attendance at the workshop. Neither does it represent the views of ENGIE or Oxera who set the scene, facilitated discussion and drafted the minutes and final paper. The "setting the scene" section at the start is designed to be a factual account of the past and present, again with some artistic licence to engage the reader. We hope you find it interesting and thought-provoking.

Back from the Future

How to sustain an efficient power system in a carbon-neutral economy in Great Britain?

Contents:

Setting the scene: the present and more recent past

As is being increasingly discussed in the UK and across Europe, the cost of gas regularly sets the price of electricity. But what happens when it doesn't?

As it stands today, the energy trilemma is acute. The three imperatives of decarbonisation, affordability and security of supply are all pulling hard, all at once. Minds are therefore rightly focussed on the here and now. And to an extent the medium term, let's say together the period 2026 – 2050.

In practice the current UK Government's energy policy priority is to decarbonise the electricity system, and fast. The plan is that more renewables and low-carbon flexibility will lead to lower and more stable customer bills, and more energy security.

The power system is the foundation of the energy transition. By decarbonising electricity supply and electrifying everything we can, we can eliminate a large portion of greenhouse gas emissions from transport and heat (as well as the things we already use electricity for).

Given the acuteness of the trilemma, the immediate question for the Government is "how can we get the renewables built and the demand and flexibility incentivised for 2030 at lowest cost?" Perhaps the next question is "how can we get the renewables built and the demand and flexibility incentivised for 2050 at lowest cost?"

However, the third question – one that is never really asked and which we sought to start answering – is "how can we sustain the power system in a carbon neutral economy – at lowest cost?"

The answer to the "how" for the first two questions since the early noughties in the UK has been to encourage investment in low carbon electricity generation at lower cost by reducing risk for investors. Of course alongside phasing out coal-fired generation.

Initially the "how" for reducing investor risk meant extra revenues on top of the electricity wholesale price – commonly known in energy jargon as a "Feed-in Tariff". Forms of Feed-in Tariffs were used to develop early-stage technologies such as onshore wind and solar power.

Since the mid-teens the "how" for lowering risk has predominantly meant fixed £/MWh revenues for intermittent or "weather driven" renewables, and fixed £/MW revenues for "dispatchable" or "flexible" power supply – i.e. the generation turn up (and/or demand turn down) that is there whenever you need it.

An attraction of the fixed £/MWh concept compared to the Feed-in Tariff is that the former "pays back" to consumers when the fixed price is above the wholesale price, rather than consumers only ever paying to "top up" the generator. This fixed £/MWh concept is known as a "two-way Contract for Difference" (CfD). The fixed £/MW concept is known as a "capacity payment". Since the mid-2010s in the UK, relevant power generators and flexibility providers have competed in auctions to secure CfDs and capacity payments. These two pillars of regular CfD and "Capacity Market" auctions are the bedrock of UK electricity policy, particularly as it relates to mass low carbon generation and security of supply.

But more is needed besides: consider new nuclear. After the one and only CfD to enable Final Investment Decision (FID) in Hinkley Point C, investors deemed it too risky to build new large-scale nuclear power stations without a guarantee that they would recover

their costs. Hence investors in Sizewell C – one of which is the UK Government - have such a guarantee, known as the "Regulated Asset Base" model. Investors in Sizewell C start getting paid as soon as they start building. Investors in Hinkley Point C - on the other hand - only start getting paid once the plant starts producing electricity for consumer use.

But more is needed besides. Electricity grids are very useful things. As everyone knows, electricity grids get electricity from where it is produced to where it is most needed. Whilst electricity grids can be a topic of complaint, nobody seriously thinks we can do without them (in the UK as a whole at least, notwithstanding individual off-grid networks). An efficient amount of electricity grid capacity brings costs down for everyone.

Less talked about is how useful electricity grids are between countries as well as within countries. It is very useful for example that consumers in England can use electricity from France when they can't get enough wind from Scotland. It was very useful that consumers in France could use electricity from England when some nuclear power stations in France were on outage in 2022.

The "how" for reducing risk for investors in inter-country electricity interconnectors is something called a "cap and floor". As the name suggests, the interconnector developer gets a guaranteed level of revenue and can keep any revenue beyond that point up until a certain point, at which point they pay back to consumers. Provided of course that the interconnector is in good working order.

But more is needed besides. The Government is providing forms of CfD to developers of (a) power stations that burn biomass; (b) gas fired power stations from which the CO2 is captured and forever buried; and (c) electrolysers that produce hydrogen from low carbon electricity. The Government has decided that a cap and floor is also needed to reduce risk for developers of long-duration (i.e. longer than eight hours) electricity storage ("LDES") facilities such as new pumped hydro stations.

Altogether - right now in the UK - we have multiple revenue support and revenue stabilisation schemes. These schemes reduce risks for investors and thereby encourage lower cost capital to flow into low carbon power generation and back-up flexibility.

Will it always be thus? Let's look behind us, then sideways, then forwards. Then we will come back from the future.

Looking back a bit further

It was not always thus. In the UK after the electricity sector was privatised and competition was introduced, the main source of revenue for power generators was the power market itself. NETA (2001) did away with additional capacity payments that existed under the Pool (1990s). NETA operated as energy-only market with the relatively small exception of the Non-Fossil Fuel Obligation (NFFO).

Yet power generation investors in the 1990s and 2000s still invested in GB. In what? Predominantly new gas fired power stations.

To the untrained eye, the centralised yet competitive UK power system of the late '90s and early noughties looked pretty good. Our existing coal-fired and nuclear power stations were supplemented and supported by a growing fleet of shiny new gas-fired power stations that could use gas from the North Sea. Electricity was reliable, secure and we didn't need to build that much extra grid to connect everything. What's not to like?

But there was one big – and ultimately existential – problem. The coal and gas fired power stations were producing greenhouse gases and warming the planet, with no incentive to do otherwise. In economist-speak, fossil fuel generators were causing "negative externalities". The "social cost of carbon" was not being priced.

Cue the EU Emissions Trading Scheme (2005) and later (2013) the UK Carbon Price Floor (CPF). These schemes were in part supposed to disincentivise CO2-emitting power stations and encourage cleaner alternatives.

Did these carbon taxes work?

Government policymakers in the mid-teens apparently thought these carbon taxes were necessary, but not sufficient. Why else would they have created the CfD and Capacity Market (CM) discussed above, which remain the bedrock of today's UK electricity policy?

But did those same policymakers think it would always be thus? Apparently not. They said that by the "late 2020s and beyond", the CfD and CM would no longer be needed because technologies will be "mature enough and the carbon price… high and sustainable enough to allow all generators to compete without intervention"[1].

[1] Implementing_Electricity_Market_Reform.pdf Page 15

Do today's policymakers agree with their predecessors? Apparently not. In 2025 the UK Government said that CfD auctions would happen every year up until 2035[2]. It also extended the CfD for wind and solar from 15 to 20 years. Leaving Hinkley Point C (which has a 35-year CfD) aside, the current Government's intent is therefore to have CfD-supported renewables until at least 2055.

Looking sideways

The UK was the pioneer of the CfD/CM bedrock. Some other countries – particularly in Europe - are following suit. We describe this market model – the one in which Government-sponsored revenue support combines with marginal and carbon pricing to deliver a cleaner, reliable power system – as the "hybrid" model.

As the name suggests, the "hybrid" model is an in-between model. What "purer" alternatives sit either side?

On one side of the hybrid model sits the "energy only" model. In the pure energy only model, the market is left alone to ensure that supply and demand meet through price signals. Marginal pricing is in general what happens when a commodity market is left alone. In the fully liberalised energy-only market, it is only the marginal price that ultimately sustains investment.

In the pure energy-only model, the potential for very high electricity prices is accepted as a possible and even necessary incentive for power generators to invest and/or consumers to change their demand. Whilst consumers might find such a proposition intimidating, proponents of the energy-only model would argue that the risk is worth the reward in system efficiency.

Also, consumers are not necessarily exposed to very high prices in an energy-only market. Both producers and consumers can shield themselves from exposure to high (or indeed low) prices by contracting with risk-taking intermediaries.

Perhaps the closest real-world example of a pure energy only market is in Texas.

At the other end of the spectrum lies the fully-regulated model. In this model, companies typically bid - via auctions or tenders run by the state - to build and/or own and/or operate power generating stations. As the state chooses how much generation to build, it naturally chooses whether and to what extent consumers are exposed to the

[2] The UK's Modern INDUSTRIAL STRATEGY - Clean Energy Industries - Sector Plan Page 86/87

actual costs of the electricity they use. There is little room for private risk-taking intermediaries in the fully regulated model.

There are examples of models that are closer to fully-regulated across the world, including Nebraska and Saudi Arabia.

Looking forwards: putting ourselves into the future

To reiterate: policymakers have chosen the hybrid model for today's electricity market in Britain. But will it always be thus? More specifically, will it be thus once the UK's economy is carbon neutral?

We at ENGIE provoked investigation by inviting a group of external stakeholders to consider the three archetypical possible futures. The group of 15-20 people was broken into three groups. Let's call the groups A, B, and C.

The groups were asked to transport themselves into an unspecified date in the future when the UK economy is wholly or mainly carbon neutral.

For the first part of the discussion, the groups were told which world they would be in. Group A was given an energy-only market, Group B was given the hybrid and Group C was given fully regulated model.

For the first discussion, the three groups were asked:

- What conditions may cause your archetype to prevail?
- How likely are such conditions to arise?
- How effective is your archetype at delivering investment and keeping consumer costs low?

But the groups were not restricted to answering these three questions; they were free to explore any issues they felt relevant to their archetype. Overall, the purpose was to get an impression of how it "felt" to be in each.

Feedback from session 1: what do you need to believe, to believe?

Energy-only

What prospect(s) did Group A see for energy-only market in a carbon-neutral economy? Here are some of their thoughts:

- **Incentives for – including permission for incentives for - carbon-free flexibility.** To believe in energy-only in a carbon-neutral economy is to believe that unabated gas generation is not needed to enable an investment case for support-free renewables and/or flexibility, or at least not very much. To believe that, strong incentives for flexibility in both supply and demand need to be allowed, even encouraged. Demand must be encouraged to meet supply, rather than supply being built ready to meet any demand: a two-way market. Such incentives would include acceptance of scarcity prices, and acceptance that opportunity cost can replace actual fuel costs as setting the marginal price rather than unabated gas. In practical terms, this could mean uncomfortably high prices for consumers if they want to use electricity when supply is scarce (e.g. dull, still days), but on the flipside consumers being paid to use electricity when there is too much of it (e.g. bulk "spilling" of rooftop solar onto the grid on sunny days). Batteries and other "two-way" assets like interconnectors will be able to take advantage of both.

- **A different investor mix?** As discussed in the scene setting section, given the need to build low carbon power at scale and speed, the UK Government has sought to attract lower cost capital. In practice this has entailed de-risking investment, encouraging those investors who require secure cash flows. Group A questioned whether the investor mix – or at least mix of investors' preferences – might change. In an economy that is already carbon-neutral following the rapid deployment of capital in the past, might a higher appetite for risk be worth the reward in this new context?

- **The discipline of a different kind of buyer.** In today's hybrid world, developers compete with each other via auctions where the public authorities choose how much to buy, in some cases at what price. In the energy-only world, it is other companies who are the buyer rather than the authorities, imposing a different discipline on developers. Given the high stakes of eliminating net carbon emissions has been achieved, there may be a case for increasing inter-company discipline (and taking the pressure off Government officials).

- **PPAs for household customers, as well as business customers?** Faced with the risk of high scarcity prices, household as well as business consumers may wish to shield themselves by contracting with risk-taking intermediaries. The risk premia may be significant; the authorities would need to accept this. By contrast, today's contractual exit fees for household consumers are relatively modest, and in some cases not applied at all. There was also a feeling that greater awareness of the cost of energy could drive greater behaviour change.

- **A different approach to novel technology: from cart-puller to free-rider?** From the Feed-In-Tariff of the noughties (and earlier-teens) to the CfDs of the (latter-)teens

and 2020s, the UK Government has nurtured new technologies with revenue support (think onshore wind, offshore wind, floating offshore wind, solar PV). As well as bringing down costs for UK consumers, this nurturing has benefited citizens across the world. An energy-only market would not envisage the UK Government continuing to play this supporting role, at least in the more explicit, direct way it has done for the past two decades.

Hybrid

What prospect(s) did Group B see for the hybrid model in a carbon-neutral economy? Here are some of their thoughts:

- **The fundamentals of the weather might play an important role in likelihood, suggesting a form of Capacity Mechanism is likely to be retained in the UK.** Group B thought that maybe it was easier to envisage a "more energy but still hybrid" model in those places without much risk of a dunkelflaute. Where it is reliably sunny - and especially where it is reliably sunny *and windy* (think Morocco) - those conditions plus shorter duration storage perhaps means less need for revenue support. In places with more risk of a dunkelflaute (like the UK), Group B was sceptical that the authorities would tolerate the scarcity pricing need to maintain security of supply without £/MW support. This being said, maybe extensive inter-country interconnection could mitigate the need.

- **The "high capex/low marginal cost" paradigm continues to drive investors to seek support for new intermittent renewables.** To the extent that the main source of mass low carbon generation involves high up-front costs and low marginal costs (like for wind and solar), investors in those technologies will remain uncomfortable with price risk. Group B perceived that existing CfD-holders being able to sell their power for pre-set prices as long as the price isn't negative would add to the challenge for investors in new unsupported assets.

- **Robust cross-economy carbon pricing supports the "more energy but still hybrid" hypothesis.** As we know, the *net* in net zero accepts that CO2 is still emitted, but it is balanced by CO2 captured and sequestered. Robust cross-economy carbon pricing helps achieve carbon neutrality at lowest cost, by allowing only those emissions that would cost the most to abate. The "last mile" of decarbonisation of the power system might be towards the end of this CO2 merit order, in which case some unabated gas may be tolerated but at significant cost. Therefore in a world of robust cross-economy carbon pricing, there may be less need for technology-specific auctions such as for hydrogen to power, abated-gas to

power and maybe even intermittent renewables if they can compete on a "levelised cost of carbon" playing field.

Fully regulated

What prospect(s) did Group C see for the fully regulated model in a carbon-neutral economy? Here are some of their thoughts:

- **The need to mitigate extraordinary risk, for example from climate change and/or security of supply and/or affordability.** The premise underlying the discussion was a world in which the UK economy is carbon neutral. But, in reality, the energy sector is – and always will be – in some form of transition. Group C thought that the fully regulated model becomes more likely when the state perceives that the best way to mitigate extraordinary risk – whatever it may be - is through more direct control. When considering extraordinary risk, minds naturally focus on downside happenings such as extreme climate events and security of supply shocks. But extraordinary risk can also be upside events, for example a game-changing technological development such as nuclear fusion.

- **Can it be made "efficient enough", given the risk imperative described above?** Group C felt that there were ways to optimise a fully regulated model, if that was what the future held. Ways to optimise would include: (1) a sophisticated and accurate system model ("a big brain") to direct investment and dispatch; (2) maintaining at least a degree of supply and demand exposure to marginal price signals; (3) mechanisms for ensuring that Government tenders and regulated returns are value for money; and (4) ensuring private asset builders/owners/operators can access Government contracts that they can trust.

- **The bottom of the slippery slope? Intervention begetting intervention becomes full regulation.** Group C felt that the fully regulated model was more likely to emerge if today's support schemes were not actively rationalised. Today BESS and demand-side response are perhaps the only two technologies that are developed largely free of revenue support. Without active effort, Group C felt that this small club is unlikely to get bigger, and might even get smaller.

Back from the future

The second discussion was different. The three groups were not told what their future would be. The three groups were instead asked to choose their own future, based on

their own subjective blend of: (a) what they thought was most likely; and (b) what they preferred.

Based on each group's chosen future, they were asked:

> *What low or no regrets actions should policymakers take, and what missteps should policymakers avoid, to ensure that the power market in a carbon neutral economy incentivises investment at lowest cost to consumers?*

In the event, there was a striking similarity between the three groups. Their feedback can be summarised together:

a) **All three groups chose a "more energy-only" (aka less intervention) version of the hybrid model. Why?** The risk of inefficiency – i.e. the getting decisions wrong (see point e below) – put people off the fully regulated model. The energy-only model was deemed unlikely, especially given the starting point[3]. Attendees did not believe that unabated scarcity pricing in an energy-only market would be tolerated by UK citizens and therefore policymakers.

   The promise of efficiency gains attracted groups to the "more energy-only" hybrid, accepting that the more regulated hybrid may still be needed in a time of extreme change like addressing climate and security of supply emergencies. Indeed, intervention is happening now and needed now to de-risk the transition, particularly to build clean power generation and the commensurate grid. Once the transition is more or less complete, it was felt that less intervention would be needed. In this future context, market forces could be given more of a role to ensure that supply and demand match most efficiently and to minimise the cost of the whole power system.

b) **What does a "more energy-only" hybrid mean in practice?** Feedback suggested that at the very least it would involve continued capacity payments to: (i) avoid intolerable scarcity pricing and; (b) address the challenge of investing in a market where there are long periods of low prices and more occasionally very high prices. Absent a degree of revenue certainty, investors may struggle to make a business case. However, groups recommended a "glide path" for bespoke low carbon dispatchable support (e.g. hydrogen-to-power) over time into a technology neutral capacity market, supported by robust cross-economy carbon pricing.

[3] By which participants meant that the cumulative effects of regulation and policy interventions have altered the capacity mix and end users' expectations that an energy-only 'reset' is difficult to imagine.

c) **Is any revenue support needed beyond capacity payments to sustain an efficient carbon neutral economy once we get there?** Participants felt that revenue support will continue to be needed to nurture novel technologies, but not necessarily provided by British consumers. Stakeholders agreed that the "high capex/low marginal cost" characteristic of weather-driven renewables will continue. Despite this, some did not see it as inevitable that today's fixed £/MWh model of support for new intermittent renewable generation would be most suitable in a carbon neutral economy. They suggested that alternatives to today's fixed £/MWh support could include: (i) enhanced incentives and visibility for investors in flexibility (which would in turn help stabilise the wholesale price and reduce price risk for renewables); and (ii) tax credits/capacity payments.

d) **Low regrets steps to help shift the hybrid to more "energy-only".** The groups agreed on more incentives and enablers for flexibility, including aggregated distribution-connected flexibility. A robust economy-wide carbon pricing mechanism was a popular choice for attendees for the reasons set out above. Other "no brainers" included: more interconnectors, universal electricity smart meters and completion of half-hourly settlement.

e) **How much central planning?** Feedback from all groups suggested that a balance needs to be struck between prescriptive central planning of supply and demand, and leaving sufficient room for a multiplicity of players innovating and competing to discover better assets, products and services. With total central planning, participants worried that the risk of the 'wrong' decision being taken increases, with a greater chance of moving away from a technology neutral approach to picking winners (which may not turn out to be so). The groups also cited (the much cited) problem that "intervention begets intervention": where an operational system problem is observed, the default seems to be to seek to control it through further intervention. The question of "how much central planning" is clearly on the Government's mind as it mulls how to meld the Strategic Spatial Energy Plan (SSEP) and Reformed National Pricing (RNP).

Wrap-up

The UK was the first country in the world to respond to the climate emergency with legally binding emissions reductions targets, culminating in the 2050 net zero target. The UK adopted policies to match its ambition and became the first major economy to halve its emissions. We are now accelerating the buildout of clean electricity, which will be the foundation of the carbon-neutral economy.

While we are focussed on pace and delivery, we need to keep our eyes on the prize: an efficient, secure, carbon-neutral future. This doesn't necessarily mean cheap energy; it means the cheapest we can get given the circumstances. We need to plan for that future sooner than you think, or it may be delayed. Or worse, never come.

Right at the start of this write-up we asked the question: "As is being increasingly discussed in the UK and across Europe, the cost of gas regularly sets the price of electricity. But what happens when it doesn't?" It is perhaps instructive that no workshop participant suggested anything other than marginal pricing continuing to be the most efficient way to match supply and demand, including in a carbon-neutral economy.